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The Design of Dual Split Type Air-Conditioner

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ABSTRACT

Dual split type air-conditioner has two kinds of system: 1. two compressors dual split type system and 2. one compressor dual split type system. Two compressors system is that there are two compressors for two indoor units in the system. One compressor system is that there is only one compressor in the system. The system design and operation control of one compressor system are more complicated than that of two compressors system. Here, we discuss the design of dual split type air-conditioner of one compressor system in mechanical aspect.

INTRODUCTION

With the development of economy and improvemnet of living conditions, people need more kinds of air-conditioner for different requirements. Dual split type air-conditioner is developed on this base. Dual split type air-conditioner is the system of using one outdoor unit and two indoor units. Each indoor unit can be controlled independently, so these two indoor units can refrigerate at the same time or only one indoor unit refrigerates. The main advantage of dual split type air-conditioner is that the outdoor unit requires small installation space. Generally, the two indoor units are same in size, hence, it is better to use these indoor units in two rooms. The space of each room is almost the same.

There are two kinds of dual split type air-conditioner: 1. two compressors kind and 2. one compressor kind. Two compressors kind is that in air-conditioner there are two compressors, which are mounted in one outdoor unit, one compressor connecting with one indoor unit. When two indoor units refrigerate at the same time, both the two compressors and two indoor units work; When one indoor unit refrigerates, only one compressor and one indoor unit work. The working and controlling ways of this kind air-conditioner are just the ways of single split type air-conditioner. Since the system structure is like the single split type's, therefore, in two compressors dual split air-conditioner, refrigerating capacity offered by each indoor unit and EER value of the air-conditioner are same and can't be affected by the other indoor unit.

One compressor dual split air-conditioner is that there is only one compressor in it. In this air-conditioner, when two indoor units refrigerate, the compressor and two indoor units

work; when one indoor unit refrigerates, the compressor and one indoor unit work. The design of this air-conditioner is more complicated, but because it only needs one compressor and can be rebuilt from single split type air-conditioner, so the cost and selling price are low. The author has desinged an air-conditioner of one compressor dual split type with refrigerating capacity of 1900W offered by each indoor unit in the two indoor units running. This paper introduces the design of this air-conditioner.

CHOICE OF MAIN EQUIPMENTS

In one compressor dual split type air-conditioner, main equipments are compressor, expansion device, heat-exchanger, fan and solenoid valve.

Compressor is an important part of the air-conditioner. It not only can effect refrigerating capacity but also can affect EER value of air-conditioner and is cheif noise source too. Rotary compressor which has advantages of small volume, low noise and high EER value, etc. is usually used in air-conditioner. In our design, we have chosen compressor C133A, which has refrigerating capacity of 3880W.

Expansion device is capillary. As expansion device, capillary has the advantages of simple construction and high reliability.

Heat-exchanger is another important part of the air-conditioner. Heat transfer efficiency of heat-exchanger directly affects the size and EER of the air-conditioner. To air-cooled heat-exchanger, fin type is used widely. This kind of heat-exchanger has small volume, high heat exchange efficiency and can be simply installed. In air-conditioner, there are two kinds of heat-exchanger, condenser and evaporator. To condenser, we use copper tube of 10 mm outside diameter. The fin outside the copper tube is 0.13 mm thick aluminium foil of wave form. To evaportor, we use copper tube of 7 mm outside diameter. The fin outside the copper tube is 0.13 mm thick aluminium foil of slotting form.

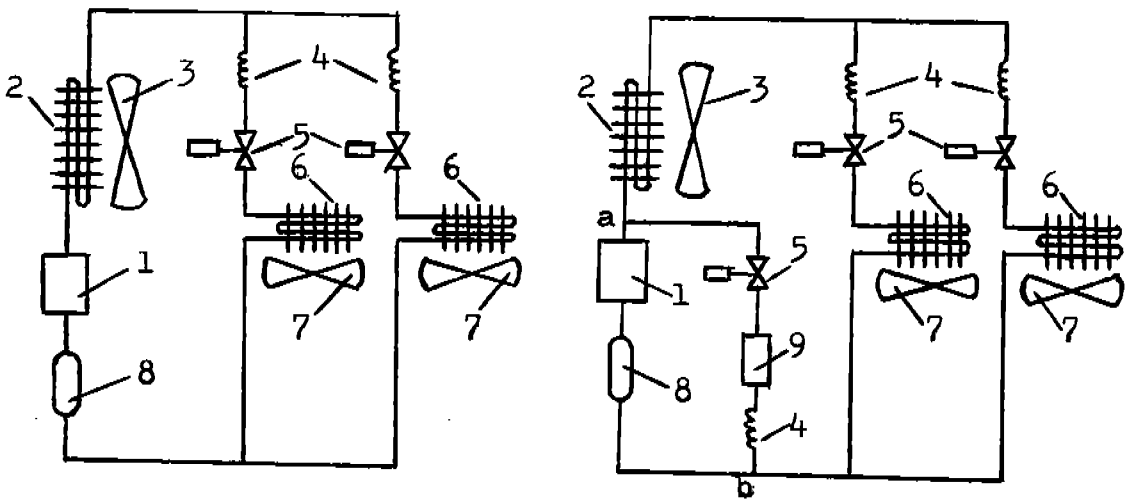
Fan and fan motor are considered as a whole. Since air flow rate and noise can affect the quality of air-conditioner, hence, we choose low noise and low speed motor. The speed of motor of outdoor unit is 860-890 rpm and the highest fan motor speed of indoor unit is 1300 rpm. Axial-flow fan is used in outdoor unit and centrifugal fan is used in indoor unit.

Because one compressor dual split type air-conditioner has only one compressor, it is necessary to add solenoid valves in the system. Refrigerant flow is controlled by operating solenoid valves. Since solenoid valve is connected with thermostate and its frequancy of start is high, hence, solenoid valve quality

must be good. We choose solenoid valves of type VD1.

DETERMINATION OF SYSTEM

To one compressor dual split air-conditioner, in the condition of compressor keeping running, there are two working ways: 1. both two indoor units refrigerating and 2. only one indoor unit running. Compared with two indoor units refrigerating, when only one indoor unit runs, the evaporating area of the air-condition reduces half. It may result in hydraulic impact due to more liquid refrigerant in the outlet of evaporator. To avoid this situation, we have brought forward two projects as shown in Fig.1.



(1). Schem of the first project

(2). Schem of the second project

1— compressor, 2— condenser, 3—fan, 4— capillary, 5— solenoid valve, 6 —evaporator, 7— fan, 8— liquid receiver, 9— receiver.

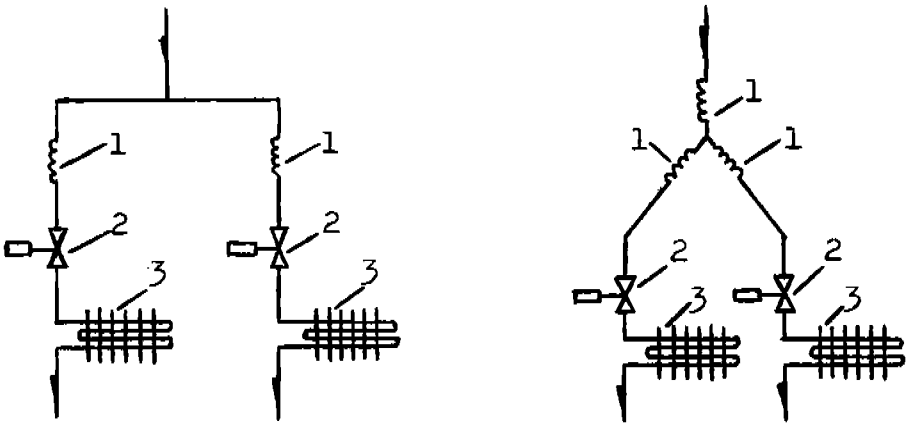
Fig.1 One Compressor Dual Split Air-conditioner

The system in Fig.1(1) is a common one, but a big liquid receiver is used. Rotary compressor itself has a liquid receiver. We have chosen a compressor in which the liquid receiver is quite big. In Fig.1(2), a bypass line connects two points a and b. When two indoor units refrigerate at the same time, the solenoid valve in the bypass line closes, so no refrigerant passes the line. When only one indoor unit refrigerates, the solenoid valve in the bypass line opens, part refrigerant vapor passes the line and back compressor. But using this way has three shortcomings: 1. Temperature of refrigerant vapor backing compressor through

the bypass line is high, so the temperature of vapor sucked in by compressor is high and it must results in high discharge temperature; 2. Refrigerant passing through the bypass line is vapor and its flow rate is limited, hence, it may not satisfy the system; 3. Manufacture is complicated.

By test, it is found that project one can satisfy the requirement of system at any conditions. Hydraulic impact dosen't occur.

CONNECTION WAYS OF CAPILLARIES



(1). The first way (2). The second way

1—capillary, 2—solenoid valve, 3—evaporator.

Fig. Schems of Connection Ways of Capillaries

In one compressor dual split type air-conditioner, refrigerant must be divided into two parts for two indoor units. We use capillary to reach this target. Using capillary can divide refrigerant and make refrigerant expand at the same time.

The simplest way is to use two capillaries, one capillary connecting with one indoor unit as shown in Fig.2(1). Another way shown in Fig.2(2) is "Y" form connection with three capillaries. To convenience of manufacture, the inside diameter and length of three capillaries are same. Here, these two connection ways are compared.

When fluid passes a tube, its pressure drop can be expressed as follows:

$$\Delta P=\lambda\frac{lv^2\rho}{2d} \quad [1]$$

where, ΔP — pressure drop,
λ — coefficient,
l — lenhth,
d — inside diameter,
v — velocity,
ρ — density of fluid.

From the equation, it is known that pressure drop ΔP is directly proportional to square velocity v^2 of refrigerant. Since velocity v is directly rpoportional to volume flow rate $\dot{V}$, that is

$$v = \frac{\dot{V}}{(\frac{1}{2}d)^2 \pi}$$

hence, ΔP is directly rpoportional to $\dot{V}^2$.

If we use the first connection ways, suppose that when two indoor units refrigerate, the volume flow rate of refrigerant out of condenser is $\dot{V}$, so the volume flow rate of refrigerant passing one capillary is $\frac{1}{2}\dot{V}$ and the pressure drop of each capillary is ΔP_1. When one indoor unit runs, the volume flow rate of refrigerant is $\dot{V}'$ and the pressure drop is $\Delta P_1'$.

Since $$\dot{V}' > \frac{1}{2}\dot{V}$$

so $$\Delta P_1' > \Delta P_1$$

When the second connection way is used, we can also obtain the following result

$$\Delta P_2' > \Delta P_2$$

where, $\Delta P_2'$ —— the pressure drop in one indoor unit running,
ΔP_2 —— the pressure drop in two indoor units running.

It has been found that pressure drop $\Delta P_2'$ in the second connection way is smaller than $\Delta P_1'$ in the first way, therefore, the second connection way is better. The reason is that the bigger is the pressure drop of refrigerant passing capillary, the lower is the evaporating pressure. Low evaporating pressure is disadvantage to refrigerating capacity and EER value of system.

Test results agree with above analyses.

THE PROBLEMS LEFT

The problems mentioned above have been solved, but there are some other problems left. The first is the problem of refrigerant leakage. Because there are more connection points in a dual split type system, the possibility of refrigerant leakage increases. The second is the problem of refrigerating capacity and EER value of the air-conditioner. Since there are two working

ways: 1. two indoor units refrigerating and 2. one indoor unit refrigerating, the refrigerating capacity and EER value of the air-conditioner are somewhat different in different working ways. We have discuss this problem in another paper.[2]

CONCLUSION

When one compressor dual split type air-conditioner is designed, the whole system and its equipments must be considered carefully. The author of this paper has designed an air-conditioner of this kind system according to the ways mentioned above. Its quality satisfies Chinese National Standard[3].

REFERENCES

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2. Wu Hongping, "EER and Refrigerating Capacity of Dual Split Type Air-conditioner", to be publised in this proceedings.
3. Chinese National Standard, "Room Air-conditioner GB7725-87".